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A STAND TO MEASURE THE ENDURANCE UNDER THE CONDITIONS OF A CONSTRAINED, LINEARLY INCREASING DEFORMATION AT A ONE CHANNEL REGISTRATION OF THE RESULTS

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When investigation the endurance of materials under the conditions of a constrained, linearly increasing deformation Δh, there is a necessity of an automatic registration of the corresponding tension $\sigma = f(\Delta h)$ arising in the point of contact between the dynamometer and the sample. If the value of the deformation change depending on time is not lineary $\frac{\Delta h}{\Delta t} \neq$ const then usually a two channel registration with application of registrator of type X, Y (where the coordinate X corresponds to the deformation Δh, the coordinate Y — to the tension σ) [2, 4, 7, 8, 15].

Under the conditions of a constrained deformation (that is when $\frac{\Delta h}{\Delta t}$ = const) the changes $\sigma = f(\Delta h)$ can be registered in a one channel system with application of the registrator Y, t if the paper in the registrator moves synchronically to the movement of the pushrod of the dynamometer spring (the dynamometer can register $\sigma = f(\Delta h)$ in such a system mentions as a sidenote [13, 14]).

As a matter of fact the system of the one channel registration $\sigma = f(\Delta h)$ in the coordinate system Y, t in based on the indirect measurement of the deformation Δh of the sample through the measurement of the summary deformation of the sample and of the spring of the dynamometer.

It can be seen from the Fig. 1 that

$$a_1+l_1+h_1 = a_2+l_2+h_2, \tag{1}$$

hence

$$\Delta a = \Delta l+\Delta h, \tag{2}$$

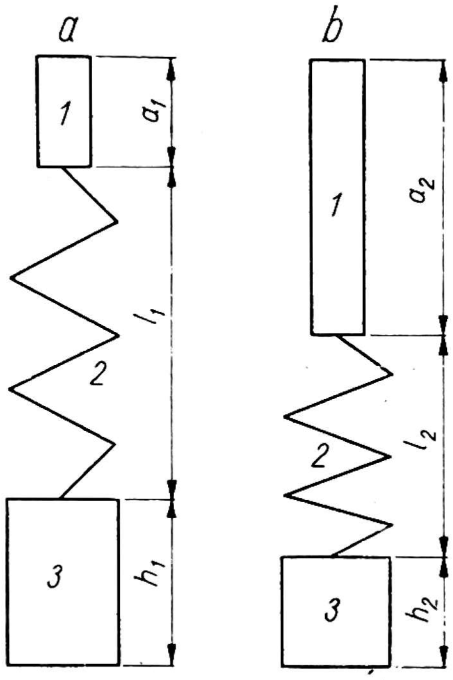

Fig. 1. Principle of measurement of deformation of the simple: *a* — non-deformed sample, *b* — deformed sample, *1* — pushrode, *2* — spring of dynamometr, *3* — sample

where Δa is the advancing of the pushrod, and as it can be from the equation (2) represents the summary deformation of the sample and of the spring of the dynamometer.

From the equation (2) we have

$$\Delta h = \Delta a - \Delta l \tag{3}$$

and

$$\sigma = \frac{F}{S} = \frac{k \cdot \Delta l}{S}, \tag{4}$$

where

F — a force arising in the point of contact between the spring and the sample,

k — a constant value characteristic for the spring,

S — surface of the contact between the sample and the dynamometer.

As it can be seen from the equations (3) and (4) the values of σ and Δh can be determined univocally by measuring Δa and Δl.

When the paper in the registrator moves synchronically to the pushrod of the dynamometer spring, then the duration time of the movement is the same and there results as follows:

$$t = \frac{L}{V_r} = \frac{\Delta a}{V_d}, \tag{5}$$

where

L — the length of the paper tape advanced from under the writer of the registrator,

V_r — the rate of the movement of the paper tape,

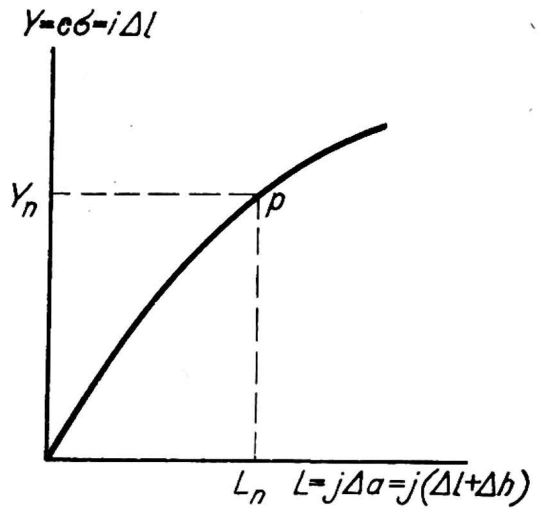

Fig. 2

V_d — the rate of the movement of the pushrod of the dynamometer. From the equation (5) we have

$$L = \frac{V_r}{V_d} \cdot \Delta a = j \cdot \Delta a. \tag{6}$$

Then it can be seen that L is the time corresponding to the duration of the deformation process. The advancing of the writer of the registrator is proportional to the tension and is equal to

$$Y = e \cdot \sigma = e \cdot \frac{k}{S} \cdot \Delta l = i \cdot \Delta l, \tag{7}$$

where e — reinforcement of channel Y.

It can be seen from the equations (6) and (7) that the registration in the coordinate system Y, t is here univocal with the registration in the coordinate system Y, L where L is proportional to Δa, and Y is proportional to σ.

If the graph is available the relationship $Y = f(L)$ we can transform the results to hte coordinate system X, Y (Fig. 2).

$$Y = \sigma = \frac{Y_n}{e}, \tag{8}$$

$$X = \Delta h = \Delta a_n - \Delta l_n = \frac{L_n}{j} - \frac{Y_n}{i}. \tag{9}$$

The transformation of the results from the registrator tape to the system X, Y can be performed on the graph if through the original point of the system the graph corresponding to the relationship $Y = f(L)$ for the ideally stiff is plotted out (Fig. 3).

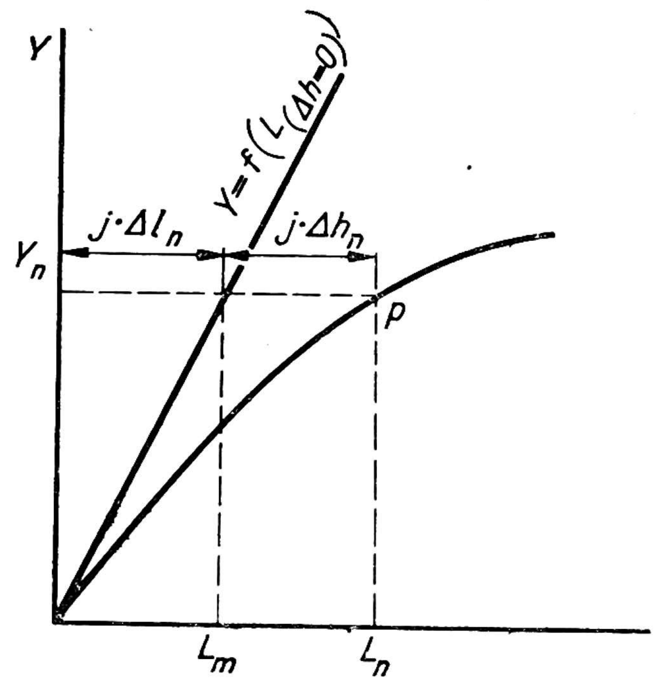

Fig. 3

As in this case $\Delta h = 0$, hence

$$L_m = j \cdot \Delta l_n$$

$$Y = f\left(\frac{L}{\Delta h} = 0\right)$$

$$L_n - L_m = j \cdot (\Delta l_n + \Delta h_m) - j \cdot \Delta l_n = \Delta h_n$$

It can be seen from the Fig. 3 that imposition of the straight line $Y = f\left(\frac{L}{\Delta h} = 0\right)$ onto the graph allows the transformation of the data to the coordinate system X, Y what can be done by a simple measuring out the corresponding segments $j \cdot \Delta h$.

The described system Y, t of the registration of the relationship $\sigma = f(\Delta h)$ is more comfortable than the system X, Y because the application of the generator of deformation Δh is not any more necessary and the manipulation connected with the exchange of samples becomes much more easy to perform. The system described can be readily realized thanks to the application of any kind of registrator Y, t.

The system of the one channel registration in the coordinate system Y, t is not suitable for the investigation with the non-linear constrainment Δh as there are difficulties to synchronize the movement of the paper tape with the movement of the pushrods of the dynamometer.

In order to form a measurement stand we used a triaxial apparatus AT with the tensometers sticked to the ring dynamometer, a tensometric bridge and a one channel registrator Y, t. The synchronization of the movement of the paper tape and of the pushrode was assured by a mechanic connection of the contact breaker and of the gear shift--lever of the driving motors of the pushrode and of the paper tape. An asynchronic three phase electric motor was used to drive the pushrode. The motor had a considerable excess of power.

The triaxial apparatus AT is one of the fundamental parts of equipment of all pedological laboratories. The use of this apparatus to construction of the above described measurement stand considerably widens the range of its hitherto applications.

The described measurement stand was applied to measure the mechanic endurance of various materials. Preliminary investigations have shown that at a relatively small costs of its construction, the apparatus assures most of those investigation possibilities which hitherto could be exclusively achieved with the help of some extremely expensive contraptions imported from the capitalistic countries (Instron).

With the help of the described measurement stand a serious of investigation problems can be solved. The following ones can be quoted here:

1. The investigation of the soils and grounds under the conditions of the triaxial tension according to the generally accepted method. Thanks to the automatic registration there is a possibility of registration the processes taking place during the cutting.

2. Investigation of deformation and of the resulting tension under the conditions of the mono-axially increasing force in the samples limited and non-limited by the cylinder walls as well as at a different value of the side tension.

With the help of the described apparatus a series of laboratory measurement was carried out.

The samples of soil of natural structure was put to deformation. The cross section surface of the samples was ten times larger than the active surface of the ending provoking the deformation (similar way of charging was previously performed by Söhne [11, 12]). Due to such conditions the laboratory experiment was carried out under the conditions similar to those under which the deformation of the soil under the wheels of tractor and under the caterpillar of tractor takes place [1, 5, 6].

Two ways of provoking the deformations was applied:

a) deformations increasing in a continuous way (Fig. 4),

b) deformations increasing in a consecutive way after the tension of a given value was arisen, the direction of the movement of pushrode was changed until the return to the zero position was achieved and then the sample was charged again (Fig. 5).

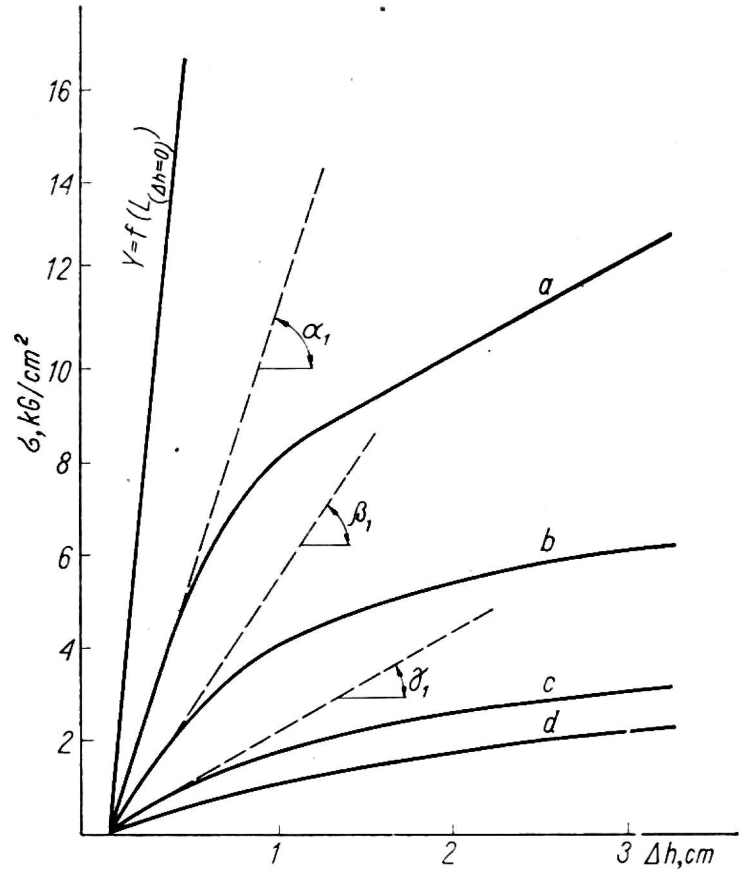

Fig. 4. Examples of registration of deformation and of tension obtained for the soil of different humidity: *a*, *b*, *c*, *d* — symbols of samples

It can be seen from Figs. 4 and 5 that the date received in this way make possible to determine:

1) elastic properties of the soil,
2) tension which provokes elastic-plastic deformations,
3) resistance force against the deformation for each of the mentioned ranges.

The range of the elastic deformation can be found from the graph on virtue of the declination angle of the curve to the axis of L (Fig. 4) as well as family of endurance histeresis assuming a maximum value of the tension still able to provoke the reversible deformation (Fig. 5).

The applicated method of measurements can usefull to determination of the soil susceptibility to deformation. The results of the investigations can be used to determine the nitary charging of the soil permissible at different kinds of agricultural works as well as to approximative determination of the loss of energy by rolling. The importance of this problem was underline in the literature [3, 5, 9, 10].

3. The apparat can be applied for investigation of the adhesive forces. Maximum sensibility of the apparatus (for the standard dynamometer) was equal to 7 G/cm² and it can be several times larger after the dynamometer is changed for another one. The apparatus is sensible enough to measure this property.

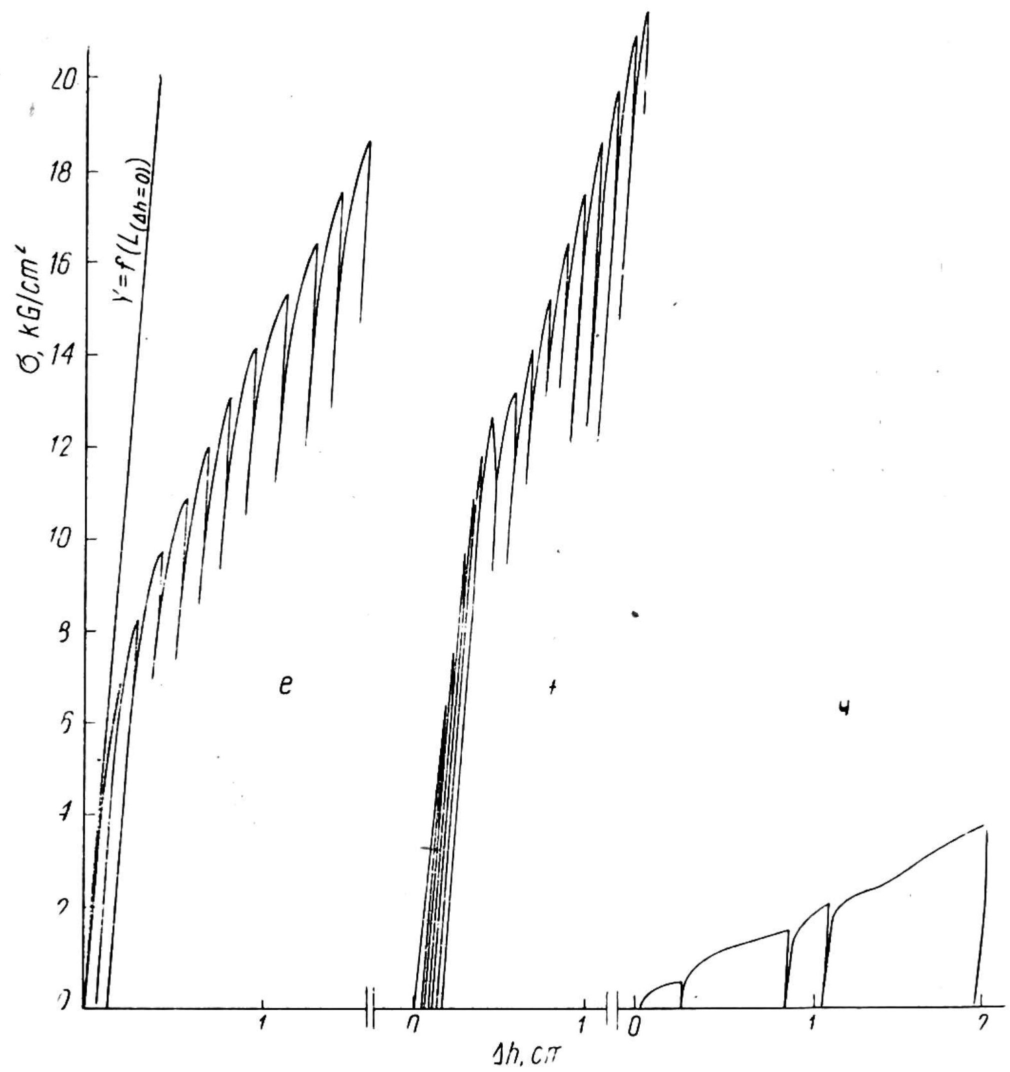

Fig. 5. Examples of a family of endurance hysteresis for the soil of different humidity: *e*, *f*, *g* — symbols of samples

4. With application of an appropriate measurement ending the apparatus can be used to the laboratory determination of the penetration resistance as well as to determination the consolidation of the soil to be found after the pressing.

5. The apparatus assures a free change of the direction of reaction of the force upwards and downwards and hence it can be used to determine the resistance of crumbling and disrupting of various materials.

6. It is worth of attention that the apparatus can be used to investigate the mechanic properties of the agricultural products. Fig. 6 represents a family of endurance hysteresis of potato. The results obtained in this way can be extremely valuable for investigation of the agricultural products considering mechanization of their harvest.

The described apparatus and the examples of its application point out for many possibilities of investigation which can be achieved with the help of the measurement stands to be found in many pedological laboratory.

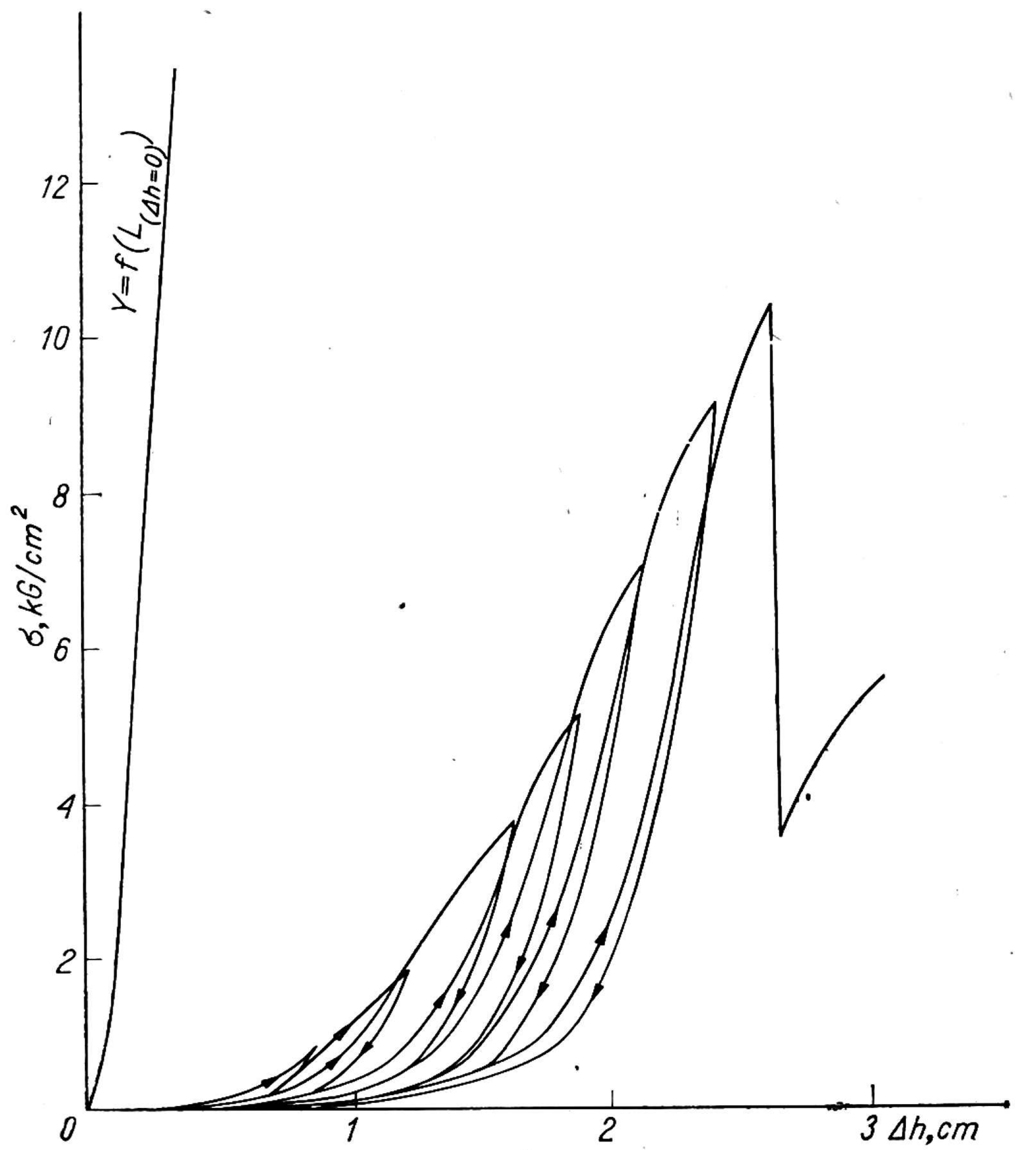

Fig. 6. An example of a family of endurance hysteresis for potato

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STANOWISKO DO BADANIA WYTRZYMAŁOŚCI W WARUNKACH WYMUSZONEGO, NARASTAJĄCEGO LINIOWO ODKSZTAŁCENIA Z JEDNOKANAŁOWĄ REJESTRACJĄ WYNIKÓW

Streszczenie

Opisano urządzenie składające się z aparatu trójosiowego, mostka tensometrycznego i rejestratora *X, t*. Jeżeli przesunięcie płytki obciążającej próbkę jest proporcjonalne do przesunięcia taśmy rejestrującej to skonstruowana aparatura pozwala na rejestrację sił i odkształceń wzdłuż osi próbki.

Г. Домжал, М. Малицки

МЕСТО ПО ИССЛЕДОВАНИЮ СОПРОТИВЛЕНИЯ В УСЛОВИЯХ ПРИНУЖДЕННОЙ ПОВЫШАЮЩЕЙСЯ ДЕФОРМАЦИИ С ОДНОКАНАЛЬНОЙ РЕГИСТРАЦИЕЙ ДАННЫХ

Резюме

Описывается устройство составленное из трехосевого аппарата, тензиометрического мостика и регистратора *X, t*. Если плита воздействующая нагрузочно на образец будет передвигаться пропорционально передвижению регистрирующей ленты, то конструированным аппаратом можно будет регистрировать силы и деформации вдоль оси образца.